

logical Council to the Scottish Meteorological Society, as are necessary for obtaining observations at stations required for the purposes of the Council; for securing the proper inspection of stations the registers from which are required for the general purposes of the Council; for the needful compilation and check of such registers; and for meeting other charges directly arising from these services; or for special researches conducted by the Society with the approval of the Council; but that no grants should be made to ordinary observers, nor for any general purposes of the society which lie beyond the scope of the operations to be placed under the Council.

23. We think that the same principle should be applied to all similar local bodies interested in the study of Meteorology; so that, in fact, no payments should be made to them except for results sought for by the Council.

24. We have indicated above in very general terms the functions of the proposed Council, and we do not think it desirable to fetter their discretion by further details. We append, however, to this report a paper by a member of the present Committee of the Royal Society, who is also a member of our Committee, stating what, according to present experience, are, in his opinion, likely to be their duties.

25. The later stages of the inquiry in relation to the transfer of oceanic meteorology to the Admiralty have raised some serious questions of expense, which the Government will, doubtless, require time to consider. We think it only just to the Committee which has heretofore had the administration of the annual grant to report our opinion that very good and valuable work is being done by it, and that if funds were provided to admit of the more responsible and more extended action of the Council, as suggested in paragraphs 9 and 22 of our Report, and if, at least provisionally, some assistance were given to the Scotch Meteorological Society, the more immediate objects referred to our Committee would be met, and there need be no interruption of the Committee's operations pending the delay, if any, which may occur, whilst the feasibility of transferring oceanic meteorology to the Admiralty is being maturely considered by her Majesty's Government.

It is important in connection with this part of the subject to bear in mind the strong claims which the Superintendent and other members of the existing staff have to continued employment.

26. In recommending the above changes we feel bound to express our sense of the great value of the disinterested services which, at the cost of much time and labour have been rendered during so many years by the Committee appointed by the Royal Society.

27. We are aware that what we are proposing is still tentative only, and we recommend, in conclusion, that there shall be a further inquiry and report at the end of (say) five years.

RESEARCHES ON THE SPECTRA OF METALLOIDS¹

THIS paper was published by Mr. Thalen after Mr. Angström's death. Mr. Thalen states, in the introduction, that only the first sheet was printed during Mr. Angström's life, who in the remainder would have liked to alter some passages and add others. Yet we take it that such alterations only would have referred to matters of detail, and that as far as the general conclusions are concerned the paper represents fairly Mr. Angström's opinion on the important questions discussed therein. Mr. Thalen has made the measurements, while the experiments were made by him in conjunction with Mr. Angström.

After a few historical remarks the authors give the following judgment on the question of double spectra:—

"We are far from denying that the lines of an incandescent gas may come out in greater number as the temperature, or perhaps only the quantity of radiating matter increases, or that some rays may increase much quicker than others in intensity. But it is certain that the assertion of various physicists that the lines originally seen may disappear altogether, and that in this way the spectrum may change completely in appearance is as unlikely from a theoretical point of view as it is contrary to experience. If such properties were real all spectroscopic researches would be rendered impossible as each element could play as far as its spectrum is concerned the parts of a Proteus.

"We do not deny that an elementary body may in certain cases give different spectra. The absorption spectrum of iodine, for instance, is quite different from its emission spectrum obtained by means of the electric spark. All bodies existing in different allotropic states will give different spectra corresponding to these different allotropic states provided that the allotropic states still exist at the temperature of incandescence.

"Oxygen, for instance, would present two different absorption spectra, one belonging to oxygen the other to ozone. But as ozone is destroyed at a high temperature, only one spectrum of incandescent oxygen can exist.

"Sulphur in the solid state exists in different allotropic states, and some observations lead us to believe that even as a gas it may exist in different states. Supposing this to be true, sulphur will give us several absorption spectra, while the possibility of a single or several emission spectra depends on the question whether the more complicated allotropic states support the temperature of incandescence.

"It is evident that the above cases do not form an exception to the general law which we have given, that an elementary body can only give one spectrum. In fact, if we suppose that the allotropic state is due to molecular constitution, it will possess from a spectroscopic point of view, all properties of a compound body, and in consequence it will be decomposed in the same manner by the disruptive discharge of electricity."

The paper then goes on to discuss the difference which is noticed in the electric spark, between the aureole and the spark itself. Messrs. Angström and Thalen sum up what they have said on the subject in the following words:—

1. There are two kinds of electric discharge, one of tension, which takes place by explosion, or disruptively, the other of quantity, which takes place by conduction, or continuously.

2. By the disruptive discharge which always takes place when the tension is sufficiently great, the body is, as a rule, torn into its smallest particles, and thus decomposed into its elements if the body is compound. The phenomenon of incandescence which accompanies both the mechanical disruption and chemical decomposition, cannot be considered as a consequence of the augmentation of temperature, but we ought rather to say that the high temperature is an effect of the mechanical and chemical force which disintegrated the body. In addition to the decomposition produced directly by the disruptive discharge, we may have chemical actions, which are, however, of a secondary nature.

3. When the electricity is conducted by conduction we must distinguish between two actions. We have actions which are entirely due to heat, and which belong to the conductors themselves. They increase with the square of the intensity of the current. We have, secondly, actions which make themselves perceptible at the surface of bodies, and which are proportional to the intensity of the current. These latter actions are confined in elementary bodies to a variation in temperature, but if the body is compound they may consist in chemical effects, which we call electrolytic actions. These two phenomena, the Peltier effect and the phenomenon of electrolysis, must be considered as different manifestations of the same force; one or other of the actions takes place according as the body is simple or compound.

These laws, which are demonstrated to hold for solid and liquid bodies, must also be applied to gaseous bodies, where we must therefore expect electrolytic actions as well as chemical ones of a secondary nature.

Our authors then go on to discuss the spectra of carbon and their compounds. They begin again with a historical statement of the work done in this respect, and as this part of the paper does not contain anything new to those who are interested in the matter we pass to the question which they propose to solve: "How are we to explain all these different spectra of carbon compounds?" They draw attention to the fact that all these spectra have a common characteristic, as they consist of bands which can be resolved into fine lines. There is, however, one spectrum which must be attributed to carbon, while the authors attribute all other spectra to carbon compounds. This spectrum is a line spectrum. It is obtained from carbon poles by means of a powerful jar.¹

If we allow a spark to pass between carbon electrodes, the lines are not seen in the middle of the field, but only close to the poles similar to the metallic lines. If the discharge pass through some carbon compound, one obtains not only these carbon lines, but also those of oxygen, hydrogen, or nitrogen, that

¹ Abstract from a paper in the "Nova Acta Regiæ Societatis Scientiarum Upsaliensis," vol. ix., 1875, by A. J. Angström and T. R. Thalen.

¹ It is the spectrum marked by Watts No. IV.—A. S.

is, all lines belonging to the elements entering into the carbon compound.

Round the electrodes of carbon we observe during the disruptive discharge an aureole, which indicates a continuous discharge. The spectrum of the aureole depends on the nature of the medium in which the discharge passes; in nitrogen we find the blue and violet groups which characterise cyanogen; in hydrogen it is the spectrum of the hydrocarbons¹ which we observe; in oxygen we get the spectrum which a Geissler tube, filled with carbonic oxide, shows.

The shaded bands of cyanogen which are situated in the blue and violet part of the spectrum, are also seen if the spark passes the luminous part of a gas flame, or in the voltaic arc between the carbon electrodes of a powerful battery. In the spectrum of the voltaic arc, however, the brilliant lines of cyanogen are mixed with those of hydrocarbons, the splendour of which is still more magnificent.

After these observations we may consider it to be a demonstrated fact that the aureole gives respectively the spectra of cyanogen, hydrocarbon, oxide of carbon, or carbonic acid, according as the gas which surrounds the electrodes consists of nitrogen, hydrogen, or oxygen. The most natural supposition is, therefore, that the spectra belong really to the compound bodies, which is the more probable as the general appearance of these spectra suggests at once an origin of compound bodies rather than of elementary bodies.

It is well known that carbonic acid is decomposed by the electric current, and that the spectrum which is observed belongs exclusively to carbonic oxide, which is formed. One might therefore imagine that carbonic acid would not have any spectrum of its own. If, however, carbonic acid is formed, as, for instance, while cyanogen burns, it appears probable that lines belonging to carbonic acid can appear, and this opinion has been confirmed by an observation of Plücker. He has found that the shaded red bands of cyanogen burning in air or in oxygen become stronger and wider as the combustion becomes stronger. An experiment made by us with a spark passing in cyanogen gas, circulating in a glass tube and freed therefrom by degrees of every trace of oxygen, has taught us that these red bands only extended to the first band of hydrocarbon, and even vanished during some instants of the experiment. The probable cause of the appearance of the spectrum of hydrocarbon in this case must be looked for in the impossibility of drying the gas completely, if it is prepared with cyanide of mercury.

It seems to us that it is much more difficult to explain the appearance of the spectrum of hydrocarbons in the combustion of any compound of carbon and hydrogen, and also, according to Mr. Atfield, in the flame of carbon disulphide. Though this spectrum was considered by some observers to be due to carbon, we cannot accept this view, and for this reason: If we employ a condenser the spectrum of coal gas shows not only the spectrum in question, but also the lines of carbon and hydrogen. The appearance of the shaded bands, being similar to those of cyanogen, shows at once, as we have repeatedly said, that the body is compound.

The difficulty, it seems to us, must in great part disappear if we could show that the same chemical compound is always formed in the combustion of any hydrocarbon. M. Berthelot has shown this to be true. According to him acetylene is formed whenever an incomplete combustion of any hydrocarbon, ether, &c., takes place, and even if the electric spark passes between carbon electrodes in hydrogen gas. It is therefore very probable that the spectrum which is formed for all carbon compounds is due to acetylene.

As far as the observation of Mr. Atfield is concerned, that oxide of carbon gives the ordinary spectrum of the hydrocarbons, we must observe that this does not agree with our own experiments. In a Geissler's tube, containing carbonic acid or carbonic oxide, one can certainly find traces of the spectrum of hydrocarbon, as the gas is never altogether dry, but according to Plücker's observation, the particular spectrum of oxide of carbon has no resemblance to it.

To the left of the Fraunhofer line G one sees generally a very strong line which really belongs to carbon. We find here the same thing which we have mentioned speaking of the spectra of the metallic oxides, that often the spectrum of the oxide is mixed with some of the lines of the elementary body.

As a second example Messrs. Angström and Thalen take the

¹ Messrs. Angström and Thalen call Swan's spectrum of the candle the spectrum of hydrocarbons.

spectrum of nitrogen. The so-called line spectrum of nitrogen was first observed by Angström, while v. d. Willigen observed a different spectrum seen in the aureole when the discharge takes place in air. The two spectra which Plücker observed were therefore not new, though he gave a new way of obtaining them. The following is a translation of the author's remarks on the origin of the two spectra:—

As to the interpretation of these two spectra we think that they only depend on the way in which the electric discharge takes place, and belong to two different bodies. The spectrum of lines caused by the disruptive discharge must be attributed to nitrogen as it appears in Geissler's tubes under the same circumstances, which accompany the disruptive discharge, but the shaded bands belong doubtless to some combination of nitrogen formed by the discharge of quantity or by conduction.

In the aureole at the positive pole we find a great number of shaded bands in which we distinguish two different series, one situated in the least refrangible part of the spectrum, and another in the green, blue, and violet parts. The appearance of these two series is different and gives rise to the suspicion that they belong to two different bodies. Whether this be true or not it is certain that their intensity varies much according to circumstances and in different ways.

At the negative pole we observe a bluish violet sheet the spectrum of which, situated in the green, blue, and violet, does not change with the nature of the electrodes.

In Geissler's tubes, containing rarefied nitrogen, we find for the continuous discharge the same spectra as in the aureoles in the atmosphere. But the positive light, which is very intense, is not only seen near the pole but also in the capillary parts of the tube. At the negative pole the bluish violet sheet gets larger and more brilliant as the exhaustion proceeds.

We now ask which combinations of nitrogen can cause the spectra of the continuous discharge? As far as the negative light is concerned we are in complete ignorance on the subject. As to the gas which is found at the positive pole one can prove by means of a solution of sulphate of iron that nitrogen dioxide is formed. It is well known that the electric spark passing through air produces the red fumes which indicate the existence of nitrous acid. It follows that nitrogen combines under these circumstances with oxygen. The only question therefore is, where does the oxygen come from in a tube filled with nitrogen? We must remember that in making nitrogen we can never entirely get rid of air, or at least there will always be a trace of aqueous vapour present, as is shown by the hydrogen line C. This fact sufficiently explains the possibility of the presence of a compound of nitrogen and oxygen. As the luminous spectrum bears no resemblance to the absorption spectrum of nitrous acid fumes, we conclude that the dioxide of nitrogen causes the shaded bands at the positive pole or in the aureole, and in the capillary part of Geissler's tube containing nitrogen. Several experiments are mentioned which have been made by the authors. Those on the spectrum of carbon run as follows:—

1. Spark between carbon electrodes in oxygen with condenser. The lines of oxygen and carbon are seen.
2. Spark between platinum electrodes, 35 mm., apart in a current of carbonic acid. Two jars used as condenser. The revolving mirror showed that the spark was instantaneous. The lines of platinum, carbon, and oxygen, were seen.
3. Same as 2. Distance of electrodes 5 mm. The aureole gave the spectrum of carbonic acid.
4. Spark between aluminium electrodes 10 mm. apart, in a current of coal gas. The lines of hydrogen, carbon, and the bands of carburetted hydrogen are seen.
5. Spark without condenser in a current of cyanogen. The lines of hydrogen, nitrogen were seen, besides the bands of carburetted hydrogen, and some bands of cyanogen.

The experiments on the spectrum of nitrogen have been made with atmospheric air. A solution of sulphate iron was used to show the presence of dioxide of nitrogen. The appearance of Geissler's tubes at various pressures are given.

Exact measurements of all the spectra discussed in the paper are given, not only for the more intense lines or bands, but exact micrometer measurements of some of the band. The names of the authors are a sufficient guarantee of the accuracy of these measurements. Excellent plates with drawings of the spectra are added. A copy of the measurements will be found in the first number of the *Beiblätter zu Poggendorff's Annalen*.

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